REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

...is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
May 25, 1994

3. REPORT TYPE AND DATES COVERED
Annual progress

4. TITLE AND SUBTITLE
Josephson Sound in Superfluid Helium

5. FUNDING NUMBERS
PE 61153N
G N00014-94-1-0043
TA 3126970---02

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Office of Naval Research
Physics Division ONR 312
800 North Quincy St.
Arlington, VA 22217-5660

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release: distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This project is directed towards the detection of an acoustical field generated near a microaperture, by quantized phase slip events in superfluid 4he. Th e annual report details the accomplishments of the first few months of this work.

14. SUBJECT TERMS
Superfluid, Josephson effect, phase slips, SQUID

15. NUMBER OF PAGES
2

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

Progress Report
Grant # N00014-94-1-0043
Josephson Acoustic Radiation in Superfluid Helium
May 1994

Brief Description:

The goal of the project is to observe an acoustical field generated near a submicron aperture, which serves as the nucleation center for superfluid quantized phase slips. The investigators seek to demonstrate that the frequency of the acoustic signal is given by $f_j = \Delta P/\rho\kappa$ where ρ is the fluid density and κ is the quantum of circulation.

Experimental Approach

The aperture is placed at one end of an acoustic resonator. Superfluid is forced through the aperture under a pressure head ΔP, a parameter which is monitorred by a very sensitive pressure transducer. The resonant cavity is terminated with a very sensitive cryogenic microphone.

Apparatus will be developed to push fluid at constant ΔP while the sound amplitude in the cavity is monitored.

Accomplishments During the Past Year

1. A prototype cell has been designed and constructed. Various aspects of the cell have been tested. The apparatus have been designed in a modular form so that individual components can be optimized separately.

2. We have developed a displacement liquid Helium pump to force superfluid through a submicron apertures for times on the order of 100 seconds. The pump consists of a flexible plastic membrane which is metal coated on one side. Application of a voltage between the membrane and a nearby fixed electrode forces the membrane to move, thus pushing superfluid through the aperture.

3. We have assembled and tested the electronics for a sensitive, freely suspended, capacitive microphone. Although we may eventually develop a SQUID based microphone we plan to go as far as possible with the simpler capacitive technology.

4. The resonant acoustical cavity has been tested by employing a piezoelectric volumetric pump to serve as a phantom for the Josephson sound. The oscillating pump creates sound in a sub millimeter sized hole.

The resonances of the cell were observed and the measured acoustic amplitudes agreed with our calculations.

5. Several Helmholtz resonance were discovered and a linear analysis of the apparatus accounted for all features. This exercise has been very useful to give us confidence that we understand all the subtleties of the acoustics.

6. A first attempt was made to measure the pressure-current characteristic of the cell. We discovered that the pressure sensor was acoustically excited by the fluid pump rendering the pressure measurement noisy and unstable. Work has begun on a stabilization scheme to decouple the fluid pump from the pressure transducer.

This measurement is necessary to permit us to determine when the aperture is producing 2π phase slips. We measure the "critical current" and, if this current varies with temperature in a certain way, we know that single phase slips occur.

7. Ambient noise effects have been studied. We have found that ambient excitation of the acoustic cavity is comparable to the expected signal. This finding has initiated consideration of factors to reduce the ambient acoustical levels, especially those generated by vacuum pumps connected to the cryostat.

8. A ^{3}He refrigerator has been designed which will run without attendant vacuum pumps. The drawings have been submitted to our shop for fabrication.

Publications
none

Students Associated With the Project
Scott Bachhaus, graduate student researcher
Tara Trumbull, undergraduate assistant

Distribution
L. Hargrove (3); Adm. Grants. Officer, ONR (1); Director, NRL (1); Defense Technical Inf. Center (2)